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SOME STRATIGRAPHIC AND STRUCTURAL FEATURES OF THE PRE-CAMBRIAN OF NORTHERN QUEBEC[1]

H. C. COOKE
Geological Survey of Canada, Ottawa

PART I

INTRODUCTION

In the present paper the writer will describe briefly the known geology of that part of northern Quebec whose four corners are the north end of Lake Timiskaming, James Bay, Lake Mistassini, and Lake St. John, with the particular object of setting forth the stratigraphic sequence and age relations of its ancient volcanic and sedimentary rocks.

This region is of especial interest on account of its development of rocks of early pre-Cambrian age. The relations existing between these rocks are shown very fully and satisfactorily, and their examination enlarges our knowledge of pre-Cambrian history and introduces corresponding changes in nomenclature. Structural work in this region, as described in this paper, demonstrates (1) a uniform sequence of extrusion in the lavas, termed the Abitibi

[1] Published by permission of the Geological Survey of Canada.

volcanics, which form the basal rocks of the region; (2) the existence of a thick sedimentary series, the Nemenjish series, which lies, so far as results at hand indicate, conformably on the surface of the lavas, and which appears to correspond to the Grenville series; (3) the occurrence of a second sedimentary series, the Mattagami series, in scattered patches unconformably on the surface of the older lavas and sediments. All of the rocks mentioned are older than the Cobalt series of the Timiskaming district, and are probably of pre-Huronian age, using the term "Huronian" as defined by the International Committee. The basal series of lavas may be of the same age as the Keewatin of the south shore of Lake Superior. The younger series of sediments (Mattagami) appears to occupy a new position in the geologic column, hitherto unfilled, between the Keewatin and the Lower Huronian of the International Committee's classification.

The region approximates in shape a rectangle 270 miles from north to south, and 350 miles from east to west (Fig. 1). Since 1908, the western third of it has been studied in considerable detail by M. E. Wilson, J. A. Bancroft, and T. L. Tanton; the greater part of the remainder has been rapidly examined by reconnaissance methods by the writer. In addition, the Chibougamau Mining Commission has examined a limited area around Lake Chibougamau in detail, and J. A. Dresser has similarly studied an area around the south end of Lake St. John. The northern Quebec region connects on the southwest with the Cobalt-Sudbury-Lake Huron region, which has been mapped in detail by Miller and Knight and W. H. Collins, so that a correlation of the whole Lake Huron-Cobalt-northern Quebec region presumably may be attempted in the near future.

This paper is merely a preliminary attempt to piece together some of the fragments of the pre-Cambrian record. The reader should remember the difficulties of deciphering this record, since the areas of ancient rocks are frequently small and disconnected, and the rocks themselves have commonly been sheared and recrystallized. As work is carried over larger areas and the number of facts for piecing out the record becomes greater, many of the conclusions stated in this paper will undoubtedly be modified or discarded. The writer considers, however, that such a concrete

generalized conception as he endeavors to present is of value, even if not wholly correct. In the words of Van Hise:[1] "The attempt to give a generalization . . . . sharpens the wits and makes the geologist think of relations which were not before observed. . . . .

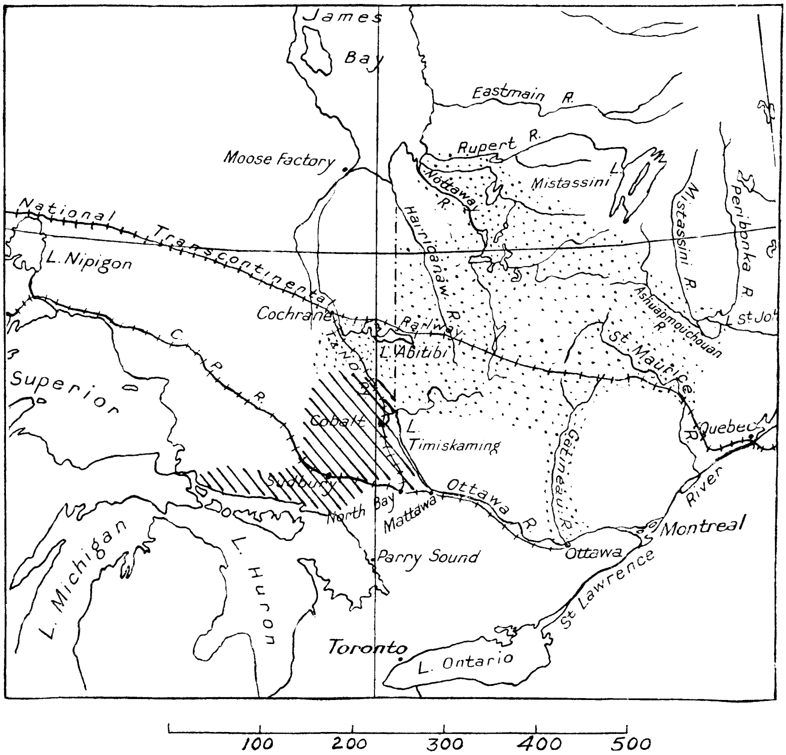

FIG. 1. Work done since 1908 in northern Ontario and Quebec. Dotted areas covered by reconnaissance methods; hatched area, by detailed methods.

He has an hypothesis or hypotheses which he is either to verify or disprove, and consequently will work with greater keenness and insight."

PREVIOUS WORK AND CORRELATION

The northern Quebec region has long been known, and a considerable amount of geographic and geologic work has been done in it

[1] Van Hise, "Principles of North American Pre-Cambrian Geology," *U.S. Geol. Surv., Ann. Rept.*, XVI, 742.

by the earlier explorers, Richardson, Bell, Low, McOuat, and others. The results of this work, which was all of a reconnaissance nature, were published by the Geological Survey of Canada in 1903 as a map entitled "A Geological Map of the Basin of the Nottaway River," on a scale of ten miles to one inch. On this map, which has been out of print for some years, the rocks were subdivided into "Laurentian" and "Huronian." The former group included gneisses, granites, diorites and diabases; the latter schists, arkose, quartzite, etc.

The work done by M. E. Wilson, J. A. Bancroft, T. L. Tanton, and the writer has since the issue of the above-mentioned map resulted in a more precise mapping of the rocks of the region according to their age relations. These geologists have refrained from attempting the correlation of the formations described by them with formations outside the limits of the region and have used local names. It follows that there is at present no literature dealing with the correlation of this area with others. This paper is the first to deal with this problem, which is of a twofold nature. The first part, which can be dealt with with some degree of certainty, is the correlation of patches of formations of similar relationships within the region itself; the second part, on which the evidence is much more scanty, is the problem of correlating these formations with others beyond the limits of the region. In the latter regard there is some recent literature that has a direct bearing on the problems of this region.

The age relations of the Cobalt series of sediments have been recently established by W. H. Collins. He has traced these sediments from the Cobalt district to the original Huronian area on the north shore of Lake Huron and shown that there they overlie unconformably the Bruce series, which appears to be identical with the Lower Huronian of the Marquette district. As a tongue of the Cobalt series projects into the southwest corner of the northern Quebec area, where it overlies the older rocks with great unconformity, this determination of Collins is of the utmost importance in fixing the age of these older rocks.

Certain ancient sediments in Ontario have been described in recent years by Coleman, Miller, Collins, and others, under the local

names of Subdury series, Timiskaming series, and Hastings series. These may eventually be correlated, altogether or in part, with the Mattagami series of the region under discussion; but lack of knowledge makes this as yet no more than an interesting possibility.

The basal lavas of this region and of the Timiskaming district have almost universally been termed "Keewatin" by various writers, but there is little good evidence for so correlating them. Like the Keewatin of Lake Superior, they occupy a basal position in the geologic column, appear to be of pre-Huronian age, and are prevailingly basaltic and andesitic in composition; but more precise evidence of identity is lacking.

In connection with the occurrence in the northern Quebec region of a series of sediments which appear to be of Grenville age, a brief statement of the present status of the Grenville series is necessary. Rocks of the Grenville series were first described by Logan in 1847, and since that time he and many other workers have studied the series and extended our knowledge of it. A summary of the different investigations is given in Van Hise and Leith's "Pre-Cambrian Geology of North America."[1] The series has been definitely recognized only in eastern Ontario, Quebec, the Adirondacks, and the little-known area of Baffin Land; and singularly enough, in these areas other surficial formations of the pre-Cambrian are lacking, excepting the comparatively small development of the Hastings series, together with certain basic lavas. It was therefore impossible definitely to correlate the Grenville with any part of the pre-Cambrian developed in the region of the Great Lakes. Recognizing this, the International Committee in 1907 adopted the following simple succession for this region:

Cambrian: Potsdam sandstone, etc.
    Unconformity
Pre-Cambrian: Grenville series
    Intrusive contact
Laurentian

In the same year Miller and Knight, of the Ontario Bureau of Mines, published a brief description of work done by them in the

[1] *U.S. Geol. Surv., Bull. No. 360*, p. 448.

vicinity of Madoc, Ontario, contributory to the problem of correlation.[1] In this paper they state that in this district "an old greenstone series, with associated acidic, igneous rocks, similar to the Keewatin of the Lake Superior region, is widely developed. . . . . It has been proved by the writer that the Keewatin here is the oldest series in the region. The limestones are found to have been deposited on the surface of the Keewatin. An ancient Keewatin lava has, in places, been subjected to little denudation before the deposition of the Grenville limestone, which fills the cracks and openings in the ropy surface of the lava." This evidence, though interesting, is scarcely convincing, principally because it assumes that the basic lava apparently underlying the limestone is correlative with the Keewatin lavas of Lake Superior region. As basic lavas are found in the Lake Superior region, not only in the Keewatin, but throughout the whole pre-Cambrian, such an assumption cannot be accepted without proof. Exception might also be taken to the validity of the evidence advanced in regard to the relative ages of the lavas and the limestones. These rocks are all tilted into vertical attitudes; so that calcite might easily be carried by meteoric water from the limestone and deposited in cracks in the lava, even though such cracks were not formed till long after the folding was completed. Again, such cracks might have formed during the folding, and the limestone have flowed into them under the pressure of deforming forces. Either of these hypotheses would explain the presence of limestone in the cracks in the lava near the contact, regardless of whether the limestone had lain above or below the lava before deformation took place.

In 1914 Miller and Knight published a more extensive paper[2] on the relationships of the rocks of eastern Ontario. In this paper they still maintain the conformable relationships of the Grenville to the "Keewatin," but without adducing much new evidence. They describe in the Actinolite-Cloyne area a nuclear mass of greenstone surrounded by Grenville sediments. Regarding the relationships of the two, they state: "In the first place it is clear that the greenstone is not a deep-seated intrusive, or batholith,

[1] *Rept. Ont. Bur. of Mines*, 1907, Part 1, p. 221.

[2] *Ibid.*, 1914, p. 2.

invading the Grenville sediments. It is a volcanic or surface rock, retaining in places an ellipsoidal or pillow structure, and a fine or medium-grained texture. In the second place the greenstone does not send dykes into the sediments, nor give other evidence of being intrusive into these rocks. It is thus *inferred* that the quartzite, greywacke, and limestone are younger than the pillow lavas." Basing upon this evidence their conclusion that the "Keewatin" is older than the Grenville, they determine the Grenville to consist, from the base up, of gray gneisses and quartzites, some of which are garnetiferous, iron formation, and crystalline limestones.

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GENERAL GEOLOGY

The oldest rocks of the district are lavas, tuffs, and sediments. The bulk of the lavas are basalts and andesites, but more acid types, such as rhyolite porphyrites, are also present, though only in relatively small amount. Like the flows the tuffs vary in composition, and are of both coarse and fine grain. The flows and tuffs have been locally metamorphosed by dynamic or thermal agencies. They are probably to be correlated with the so-called "Keewatin" of Timiskaming district to the southwest; that they are of the same age as the Keewatin of the Lake Superior district has not yet been established.

The sediments associated with the volcanics are all more or less recrystallized and are now chiefly represented by garnetiferous and non-garnetiferous biotite gneisses, garnetiferous and non-garnetiferous hornblende gneisses, and crystalline limestones. These rocks probably are the metamorphic equivalents of impure sandstones, shales, and limestones. The original nature of the hornblende gneisses is not fully established, but from the entire absence of any evidence of igneous origin they are tentatively assumed to have been sediments. The clastic beds grade downward into beds of more tuffaceous composition, which lie conformably on the surface of the lavas. Evidence has been obtained that seems to indicate that these sediments, which have been termed the Nemenjish series, form the northern equivalent of the Grenville series of eastern Ontario and the Adirondacks.

In the vicinity of Lake St. John a granite is reported by J. A. Dresser to intrude the Grenville series and to be cut in turn by anorthosite. This granite has not been definitely shown to occur anywhere else throughout the region under discussion, but the reports of Adams, Cushing, and others suggest that it is found in areas to the east and south.

Younger than the granite just mentioned, and intrusive into it and the Grenville series, are great bodies of anorthosite and gabbro. Several of these are found in the area under discussion.

A few small patches of a younger sedimentary formation are found here and there throughout the region. These have hitherto been known by various local names, such as the Pontiac, Mattagami, and Broadback series. They include mainly conglomerate, arkose, and greywacke, and lie unconformably on all the older rocks, with the possible exception of the anorthosites. They are highly folded and metamorphosed, so that even the most competent of the rocks are converted into schists.

Following the deposition of these sediments came an intrusion of lamprophyre dykes. They are relatively few in number, but their distribution appears fairly general. Next in age are the enormous batholithic intrusions of granite, which now underlie about one-half of the region. It is possible that these may be of different ages, but no evidence of this has as yet been found. The intrusion of the batholiths probably followed closely the orogenic movements which folded the older rocks. They seem to have removed by stoping and digestion enormous thicknesses of the older rocks, including all of the ancient floor on which these were laid down, and undoubtedly also had a certain metamorphosing action on the adjacent rocks.

The Cobalt series, of Huronian age, rests with great unconformity on the surface of the complex described above. It is definitely recognized only in the southwest corner of the region, but a few small areas of similar rocks occur on Chibougamau Lake, and in the report of the Chibougamau Mining Commission were correlated with the Cobalt series.

Dykes of diabase petrographically similar to the Cobalt diabase cut the Cobalt series and all the older rocks. They are found sparsely distributed throughout the entire region. The diabase here never forms sills as in the flat-bedded rocks of the Cobalt region; hence the chance of mineralization by it is slight.

The youngest consolidated formation in the area is supposedly the flat-lying Mistassini limestone, which outcrops around Lake Mistassini and has been described by A. P. Low and the Chibouga-

mau Mining Commission. Because of its undeformed character and the presence of indistinct fossil-like forms, this formation has been placed tentatively in the late pre-Cambrian or early Paleozoic.

The geological succession, therefore, is as follows:

Mistassini limestones
    Unconformity ?
Diabase dykes
Cobalt series (includes Chibougamau formation ?)
    Great unconformity
Granite
    Intrusive contact
Lamprophyre dykes
    Intrusive contact
Sedimentary series (Pontiac series, Mattagami series, etc.)
    Unconformity
Gabbro and anorthosite
    Intrusive contact
Granite gneiss (around Lake St. John)
Intrusive contact
Nemenjish series
Abitibi volcanics (basalts, andesites, rhyolites)

METHODS OF DETERMINING STRUCTURE IN LAVA FLOWS

The lavas of the region afford exceptional opportunities for structural determination, since they have suffered relatively little deformation beyond a change in attitude. Each flow has moved as a unit during the folding, so that shearing has been confined to a marginal belt from one to ten feet in width. In the remaining portions of the flows the original structures and textures remain largely unchanged and can be used for determining the structure. The lack of deformation is undoubtedly due to the thickness of the flows, which has made them very competent to resist the deforming influences. The latter have been powerful enough to convert the conglomerate, arkose, and greywacke of the overlying Mattagami series into schist.

Grain and pillow or ellipsoidal structure were the structures and textures used in determining the attitude of the flows. Amygdaloidal textures, so frequently useful for the purpose, are not found here, since the margins of the flows are almost invariably schistose.

Pillow structure.—Pillow structure is well developed in the lavas over a large portion of the region, more particularly in the andesitic types, which commonly have large pillows from two to three feet in length. The basaltic lavas for some reason do not seem to form large pillows, the maximum observed being one foot in length; and on account of the blackness of the basalt it is more difficult to recognize and examine the pillows except on unusually clean, wave-washed surfaces.

A section made from top to bottom across an andesite flow about 130 feet thick on Windy Lake showed the following arrangement: At the top there is the usual narrow, schistose zone, below which there is a zone of pillows about 70 feet in width. At the top the pillows are from two to three feet in length; they gradually decrease in size, till near the middle of the flow they attain their minimum length of ten inches to one foot. Here the pillow structure ceases rather abruptly and passes into a fragmental zone about six feet in width. This is a true volcanic breccia, made up of fragments of fine-grained lava up to six inches in diameter imbedded in a matrix of lava of somewhat coarse grain. Some of these fragments are encircled by a whorl of lava about an inch in width, in which flow textures are prominent, as if the fragment had been revolving in the viscous lava. Below the zone of breccia, fine-grained massive lava occurs. The grain of this gradually increases in size as far as the bottom of the flow, where a grain of approximately 1 mm. is attained. This massive, relatively coarse-grained lava was observed in contact with the glassy, ellipsoidal surface of the adjacent underlying flow.

Only one perfect section across the whole width of a thick flow was observed, but a large number of partial sections were obtained, and the data are sufficient to show that the above represents the section wherever the flow is sufficiently thick to possess a massive base as well as a pillowed top. The succession described may therefore be used to indicate the position of the top of a tilted flow, even where only a part of the flow is visible. Of course this method is useless in flows pillowed throughout their entire thickness.

The method of determining the position of the upper surface of the flows from the flattening of the pillows, described by Daly,

Ransome, Russell, and M. E. Wilson, proved so difficult and uncertain of application that it was not used. That flattening is greater on the under side than on the upper was clear in most cases only when the position of the upper side had been previously determined by other means.

Grain.—A progressive increase in grain takes place in passing from the top of the flow toward its base. At the top the lava is

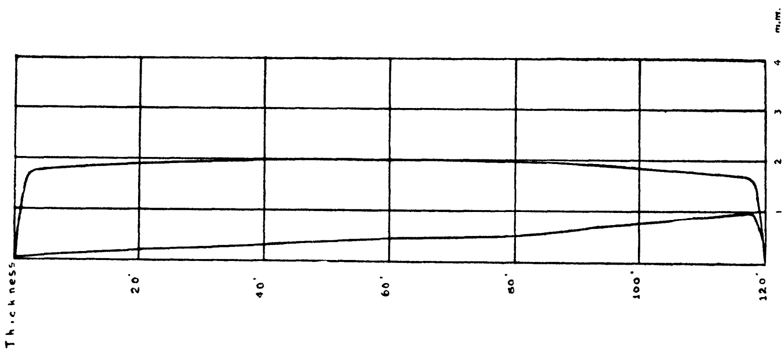

FIG. 2.—The curve to the left shows the change of grain in depth of a non-ellipsoidal andesite flow. The curve to the right is that for an intrusive of the same, thickness and composition. The maximum grain of the latter will of course vary, and may be much larger than represented.

almost or quite glassy, and the grain gradually increases in coarseness with depth till the maximum of approximately 1 mm. (in andesite) is attained a few inches from the bottom, where a narrow chilled edge is found. In the pillow lavas the fine, glassy grain persists throughout the whole thickness of the ellipsoidal zone. The curve in Fig. 2 shows the change in grain with depth of a non-ellipsoidal flow. For comparison the type of curve for an intrusive of the same composition and thickness is introduced.

It is obvious that if a sufficiently wide section can be obtained across the outcrop of a flow to show this change in grain the position of the top will be indicated. This, however, is only occasionally found possible in practice. The method is more applicable to the basaltic flows than the andesites, as their maximum grain is apt to be larger.

The methods of determining the positions of the upper surfaces of the lava flows may be summarized as follows:

A. In a single flow
   1. From changes in pillow structure with depth
   2. From changes of grain with depth

B. At contact of two flows
   1. From observation of a coarse-grained, non-ellipsoidal base resting on an ellipsoidal upper surface
   2. From observation of a coarse-grained base resting on a fine grained upper surface

The latter two methods are much the most useful.

[*To be continued*]